IC³

Interdisciplinary
Centre on
Climate Change

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Waterloo

2nd Workshop on
Parameterization of
Lakes
Norrköping, Sweden
15-17 September 2010

Exploitation of EO-Based Technology for Improving the Characterization of Lake and River Ice Dynamics in Weather Forecasting, Climate and Hydrologic Models –
ESA's STSE "North Hydrology" Project

Project Partners

North Hydrology - Goal

- The overall goal of the *North Hydrology* is to support the international efforts coordinated by the CliC project of the WCRP to exploit the use of EO technology, models and in situ data to improve the characterization of river and lake ice processes and their contribution to the Northern Hydrology system.

- *North Hydrology* aims to develop a Portfolio of novel multi-mission geo-information products (maximizing the use of ESA data), improving the current characterization of river and lakes ice dynamics to enhance NWP and modeling of key hydrological processes in Northern latitudes.

- Project duration: 24 months
- Start date: 1 July 2010

North Hydrology – Objectives

1. Develop and validate a dedicated Portfolio of novel EO-based products (maximizing the use of ESA data) responding to:

   a) The scientific requirements of the CliC community and the operational requirements of the weather and climate operational agencies to better characterize the rivers and lakes ice contribution to the northern weather, climate and hydrology system at global, national and regional scales.
   b) The scientific requirements of the operational user community (e.g., water authorities, hydrological services) to better characterize the river-ice (and glacial temporary lakes) dynamics in flood forecasting models at basin scales.

1. Assess and demonstrate the impact of the developed products to improve:
   a) NWP (at national/regional scale) and
   b) flood forecasting (at basin scale) by adjusting suitable models being able to exploit the *North Hydrology* products and performing dedicated observation system experiments and sensitivity analysis.

North Hydrology – Objectives

3. Assess in close collaboration with the scientific and user community the potential impact of the *North Hydrology* portfolio in different application areas including: climate, estimation of the river streamflow into the Arctic, navigation, ecosystem protection, etc.

4. Develop a Scientific Roadmap identifying further research and devolvement activities and potential steps to support the transition towards the operational use of the developed products and other potential developments as basis for further ESA activities in support of the CliC community.

5. Develop a web-based *North Hydrology* Science Data Portal that provides valuable data and information to the current CliC community and the general user community.

Theme1: *Global to regional scale medium resolution lake and river ice characterization for NWP, climate and regional hydrological studies.*

> The objective is to **develop and validate a novel global/regional lake and river ice product dataset (called Global Portfolio) aimed at characterizing lake and river ice dynamics to enhance NWP, climate and hydrological models at continental, national and regional** scales.

Theme 2: *Basin scale river ice characterization for flood forecasting and early warning systems.*

> The objective is to **develop and validate a novel high-resolution river (and glacier) ice product dataset (called <u>Basin Scale Portfolio</u>) aimed at addressing the needs of both water authorities and hydrological services operating flood forecasting systems.**
> **This will involve two main applications: River ice dynamics and ice jams characterization for improving flood forecasting and early warning systems; Glacial temporary lakes characterization for improving Jökulhlaups (glacial floods) forecasting.**

North Hydrology – Justification

Average evaporation patterns for a region with no lakes and a region with lakes
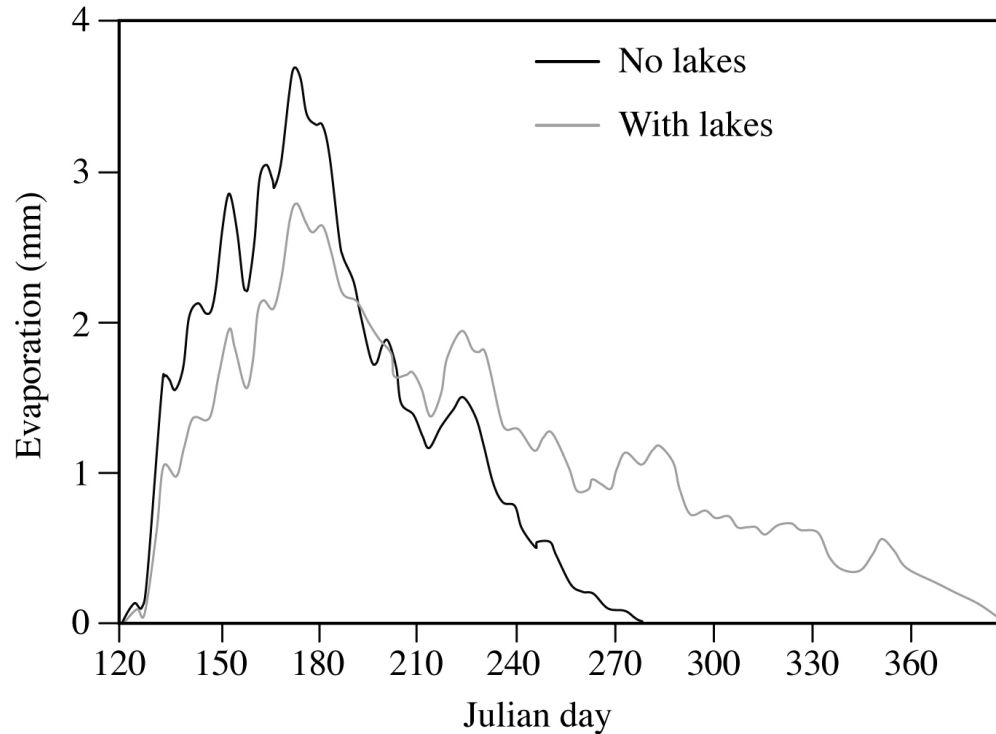

MAGS results

Rouse, W.R., Binyamin, J., Blanker, P.D., Bussières, N., Duguay, C.R., Oswald, C.J., Schertzer, W.M. and Spence, C. 2008b: The influence of lakes on the regional energy and water balance of the central Mackenzie. Chapter 18 in *Cold Region Atmospheric and Hydrologic Studies: The Mackenzie GEWEX Experience Vol 1, 309-325.*
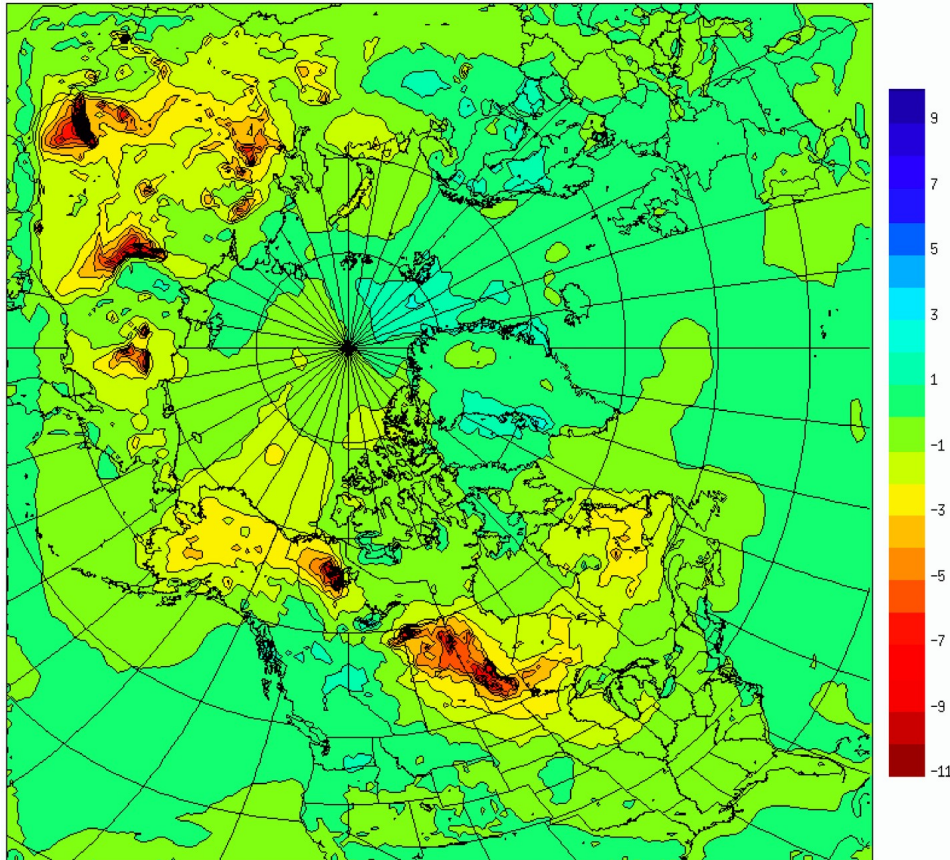
North Hydrology – Justification

Ice cover fraction has a major influence on the magnitude of lake-atmosphere exchanges in winter at northern latitudes

MAGS results

Great Slave Lake (Canada)
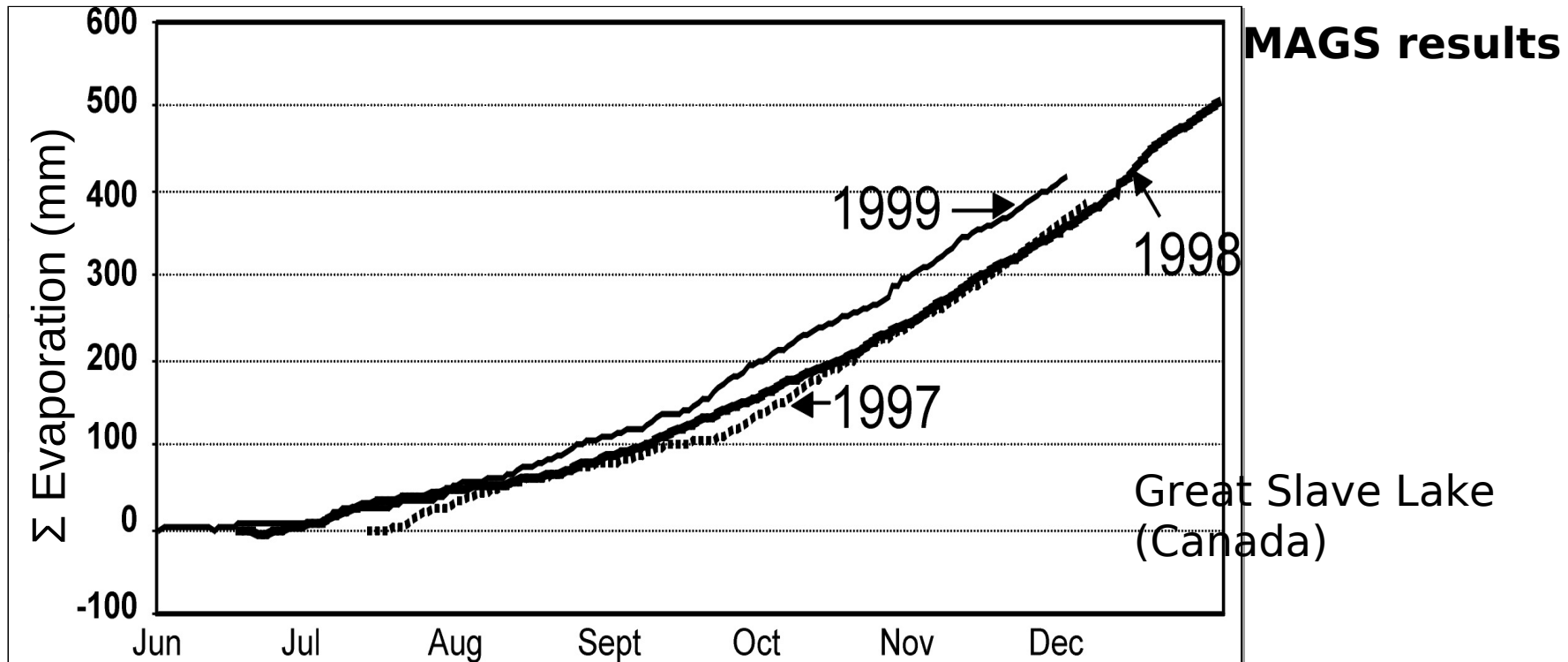
North Hydrology – Justification

Impact of lakes on weather and climate predictions

Mean winter temperature difference (^{o}C)
(with ice – no ice)

- **Improper representation of lake ice can lead to substantial errors in weather and climate models (e.g. air temperature, lake effect snowfall).**

- **Improved representation of ice and snow on ice is needed.**

GEM-LAM, 2.5 km with AMIP II

(Source: Winger and Brown, pers. comm., 2008)

North Hydrology – Global Portfolio

1. **Lake ice cover characterization (medium size to large lakes)**

a) *Development of EO-based lake ice cover algorithms/methods*

- Ice cover and open water extent, ice classification, and lake surface temperature

b) *Validation/cross-comparison of products*

c) *Evaluation of EO products in NWP model and RCM experiments*

- HIRLAM (High Resolution Limited Area Model) experiments and RCA/RCAO (Rossby Centre Atmospheric/Ocean) model experiments

Global Portfolio

⭐ Large lakes

☐ Areas with small, shallow lakes

— Major rivers

🗺 Country (Finland)

Basin Scale Portfolio

🟦 Towns

☐ Jökulhlaups

— Rivers

50°N
60°N
80°N
60°W
100°E
20°E

Table 1. Global Portfolio: Lake products for 10 major lakes in the Arctic System distributed globally.

EO Product	Spatial Resolution	Sensor/Data	Proposed Major Arctic lakes
Ice cover/open water extent	300 m 150 m	MERIS ASAR (WS)	Canada: Great Slave Lake Great Bear Lake
Lake surface temperature	1 km	AATSR	Lake Athabasca Lake Nittiling Lake Amadjuak Russia: Lake Ladoga Lake Onega Lake Taymyr Lake Baikal Sweden: Lake Vänern

Table 2. Global Portfolio: Lake products for country and/or regions with focus on ESA member states.

EO Product	Spatial Resolution	Sensor/Data	Proposed Country/Large Regions
Ice cover/open water extent	300 m 150 m	MERIS ASAR (WS)	Full country: Finland
Lake surface temperature	1 km	AATSR	*Large region: Experimental Lake Area, CAN**
* This region has been proposed as a secondary site by M. Mackay of Environment Canada who is developing a lake scheme for the Canadian RCM. The region is located at 49.67 N, 93.75 W in the Boreal Forest and is approximately 50 km x 50 km. Field validation data are available at this site.			

Great Slave Lake – Break-up
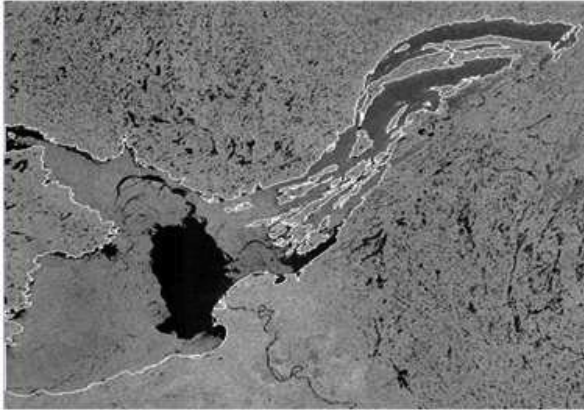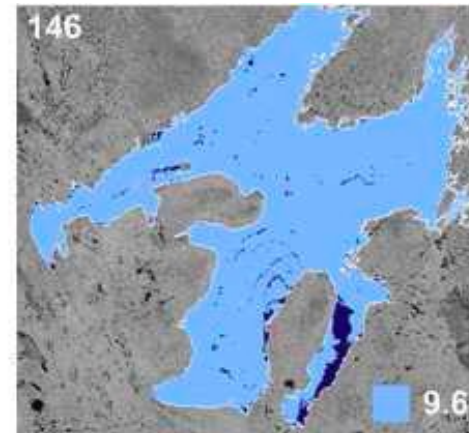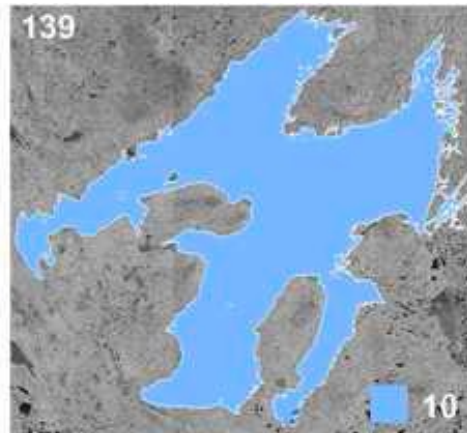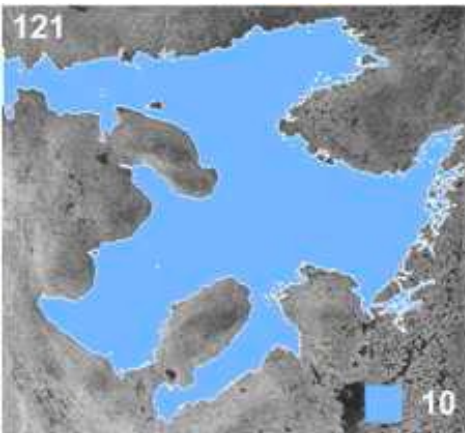

(a)

(b)
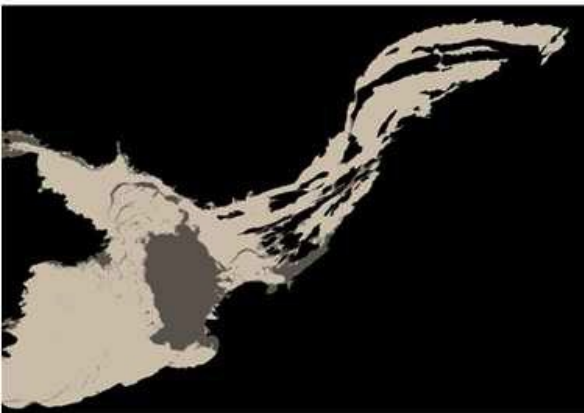
(c)
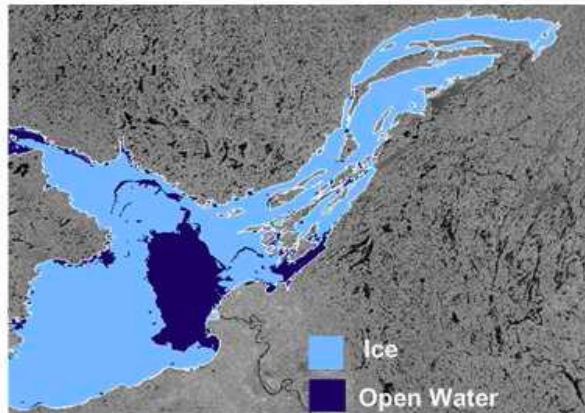
(d)

First Results
Fully automated ice
segmentation using
Radarsat ScanSAR

Ochilov et al., in prep

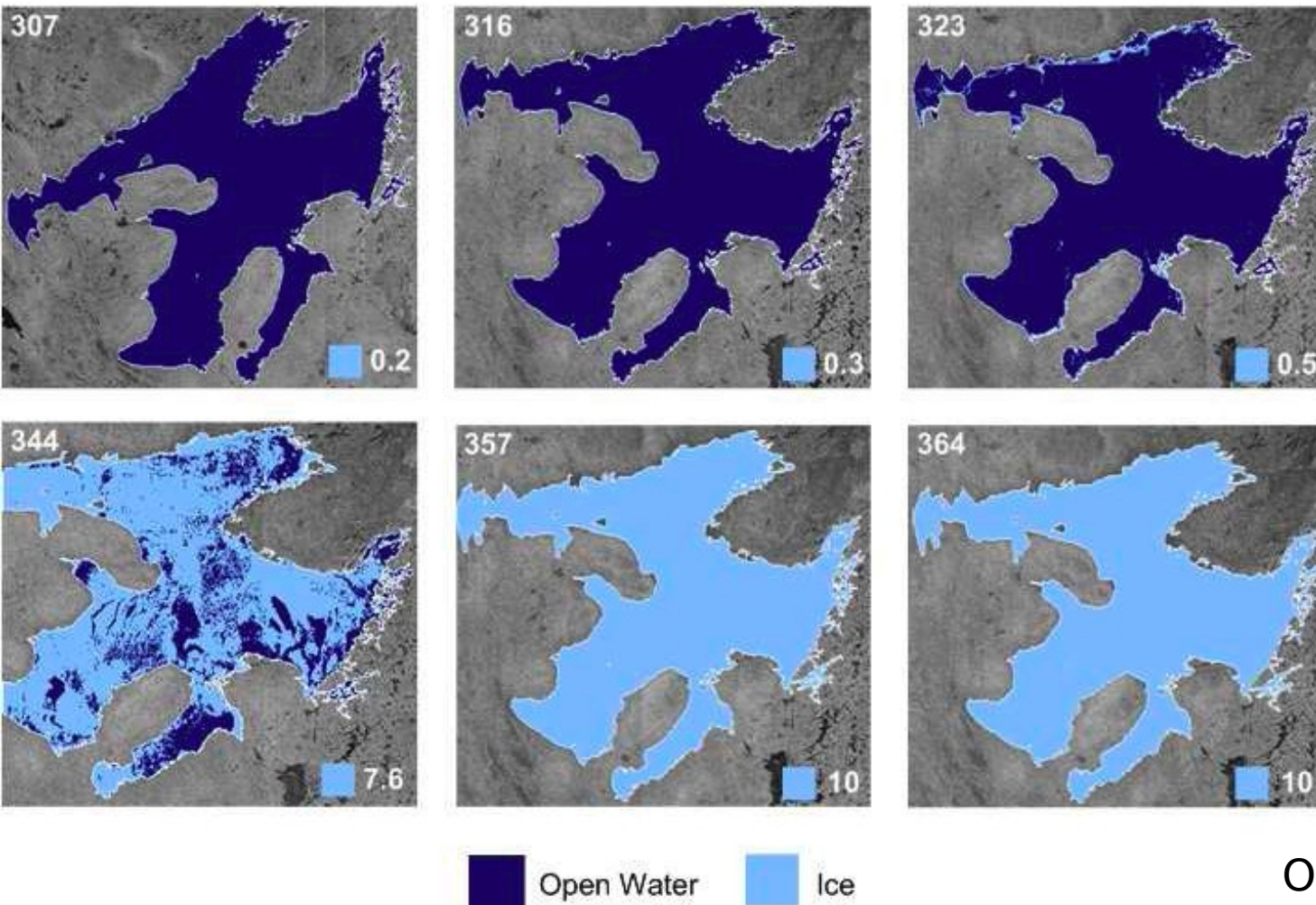# *North Hydrology* – Lake Ice Product

Great Bear Lake – Break-up
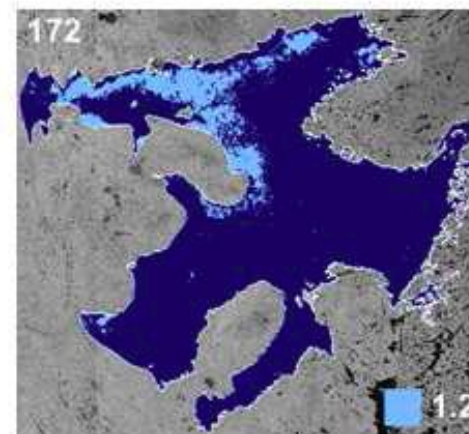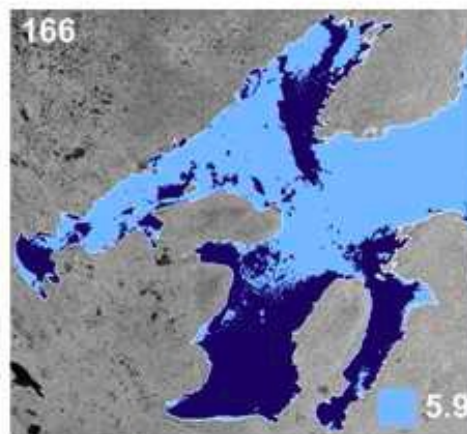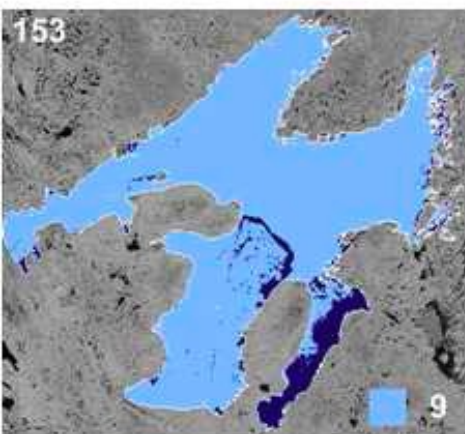
(a)

(b)

(c)

(d)

Ice

Open Water

First Results

Fully automated ice segmentation
using Radarsat ScanSAR

Ochilov et al., in prep.

Great Bear Lake – Break-up

First Results
Ice cover time
series from
Radarsat
ScanSAR

Ochilov et al., in prep

North Hydrology – Lake Ice Product

Great Bear Lake – Freeze-up

First Results
Ice cover time series from Radarsat ScanSAR

Ochilov et al., in prep

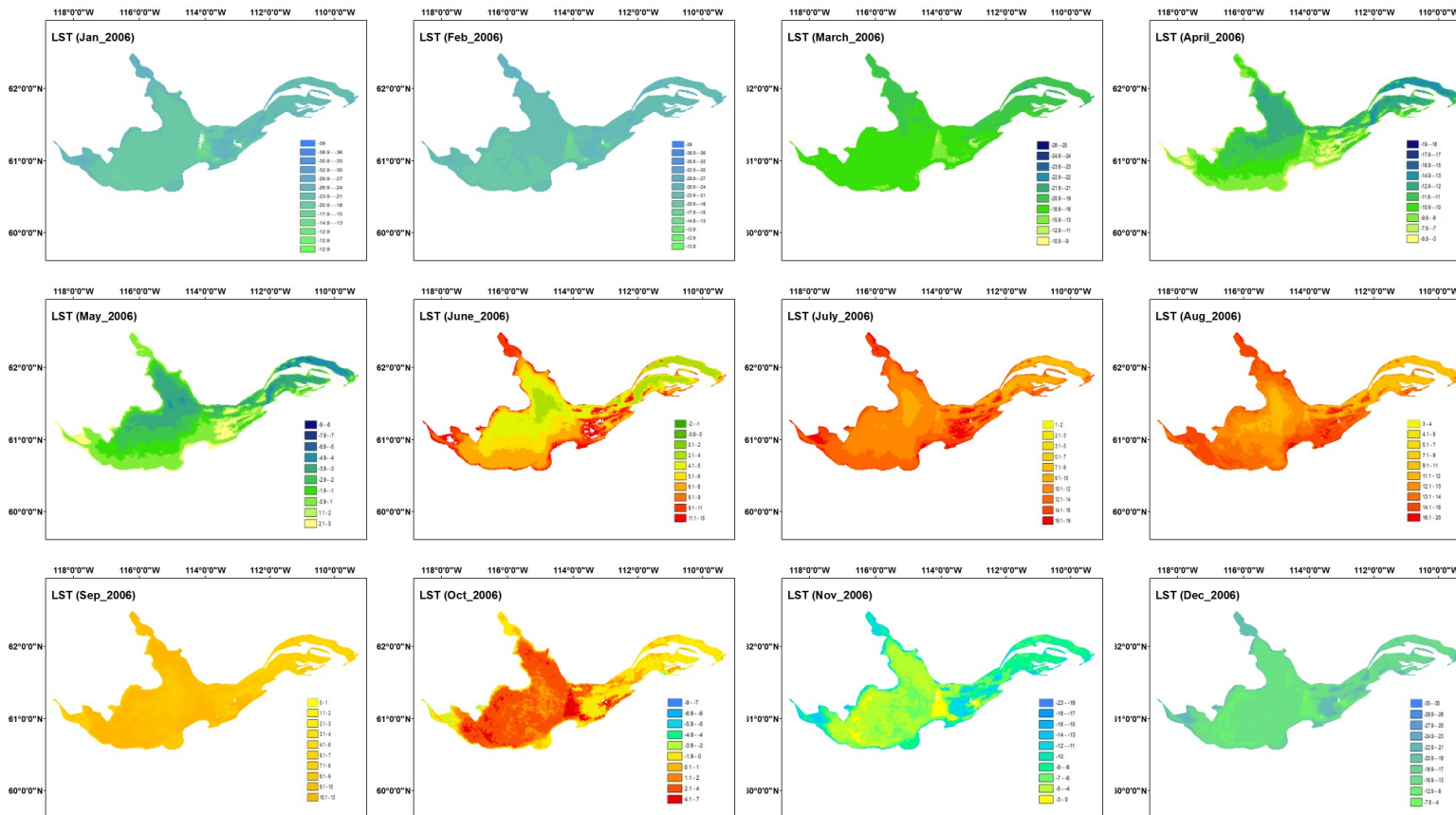## Great Slave Lake

MODIS-Derived Lake Surface Temperature

**See presentation by Homa
Thursday afternoon**

Kheyrollah Pour and Duguay, in prep.

North Hydrology – LST Product

Great Slave Lake
MODIS-Derived Lake Surface Temperature (Monthly 2006)

See presentation by Homa Thursday afternoon

Kheyrollh Pour and Duguay, in prep.

2. Lake ice cover characterization (small, shallow, lakes)

a) Lake ice cover algorithms (Duguay and Lafleur, 2003)

- Floating vs grounded ice (ice thickness)

b) Experimental dataset and validation/cross-comparison

c) Response of ice cover to climate

- Long time series of ERS-1/2 and Envisat

Table 3. Global Portfolio: Lake ice cover products on small, shallow, lakes that occupy a significant portion of the landscape.

| EO Product	Spatial Resolution	Sensor/Data	Proposed Geographical Area
Ice thickness* (floating vs. grounded ice)	30-150 m	ASAR (AP/WS) ERS-1/2	North Slope of Alaska, Alaska, United States
* Other products such as ice-on and ice-off dates can be generated as well for the same winter time period.			

North Hydrology– Lake Ice Product

April 20, 1993
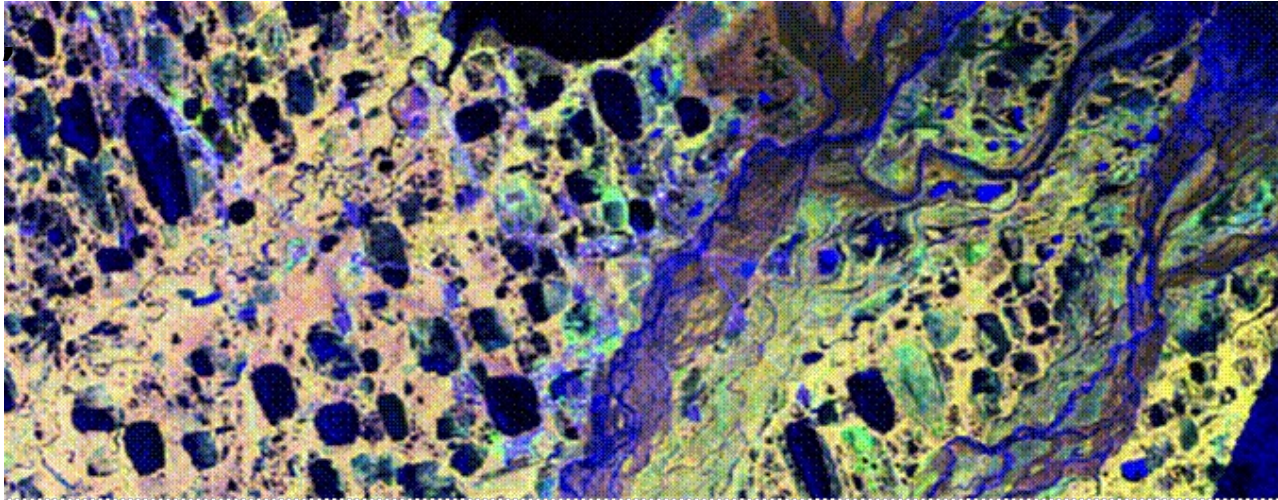
April 16, 2003

Climate Severity Inter-annual variability (ERS-1/2 – 30 m res.)
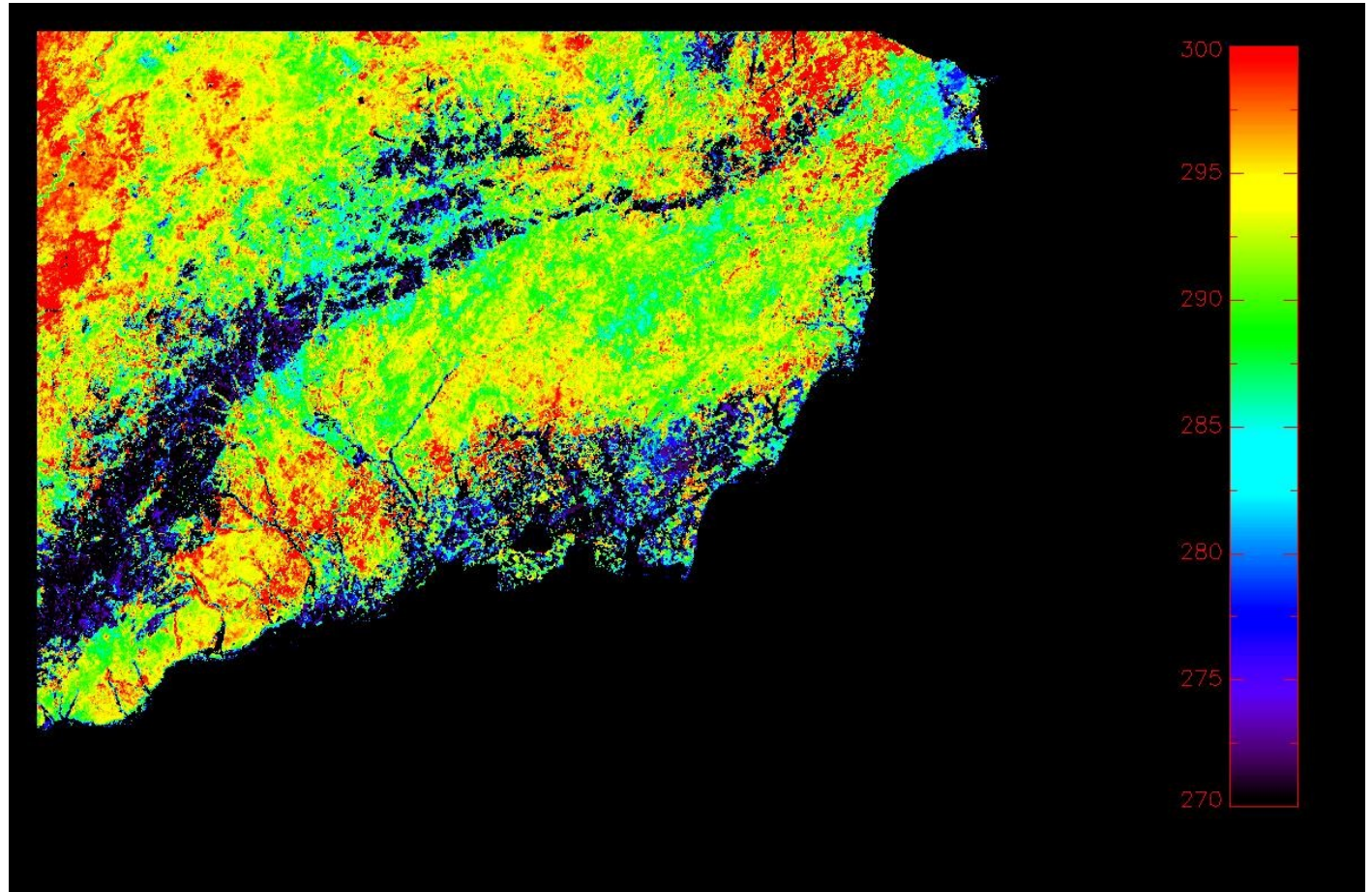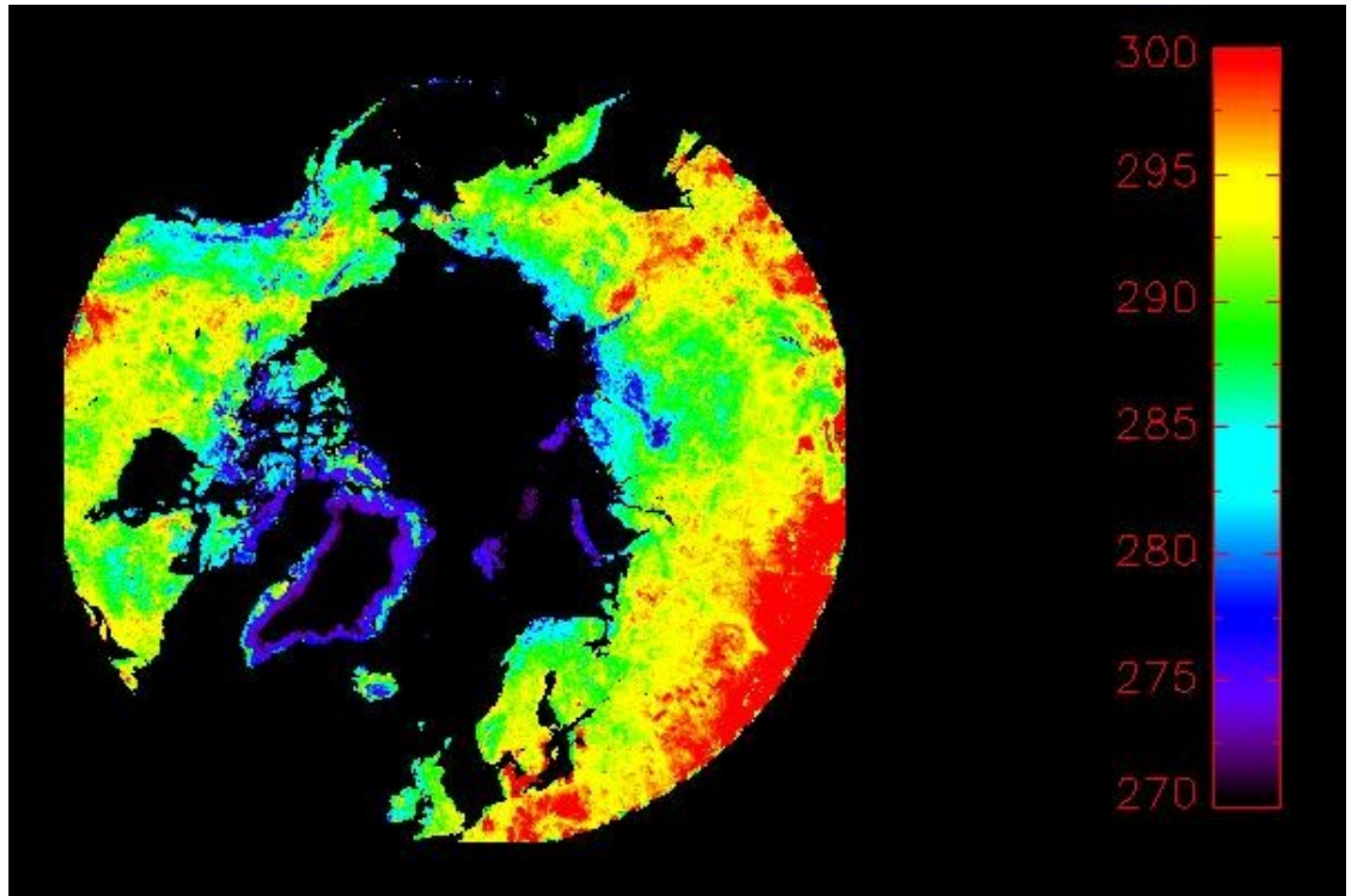(Floating vs grounded ice with SAR – Sag River,
North Slope of Alaska)
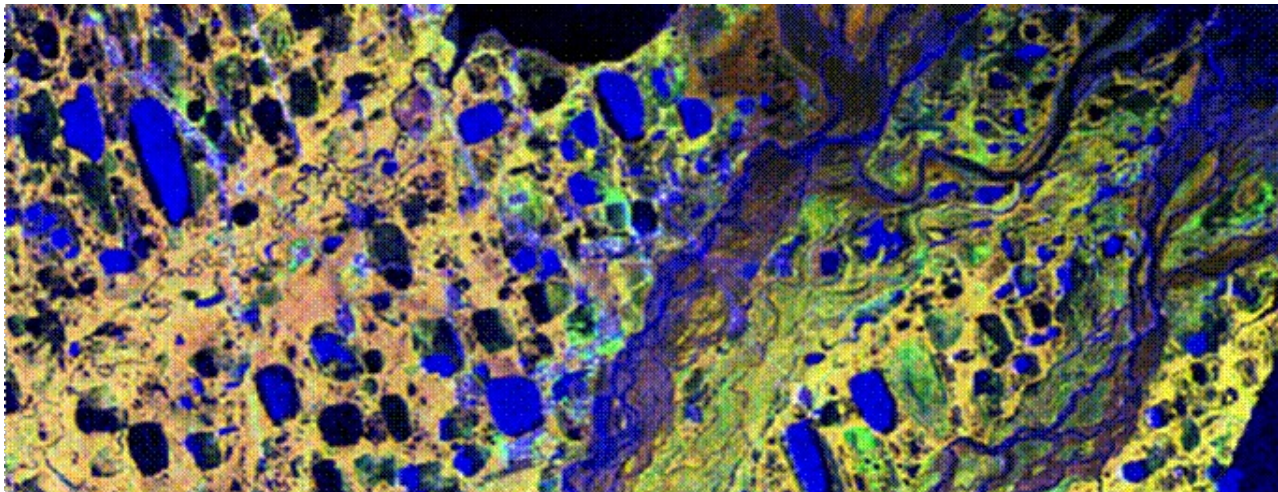
Other products generated by UW

LST MONTHLY
MEAN – AATSR
(JULY 2008) –
1 km resolution

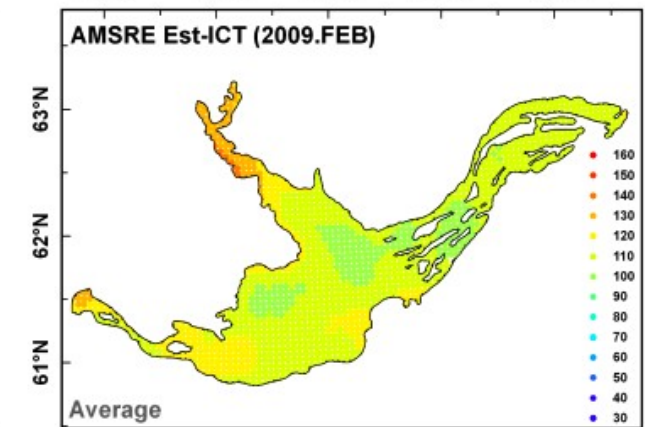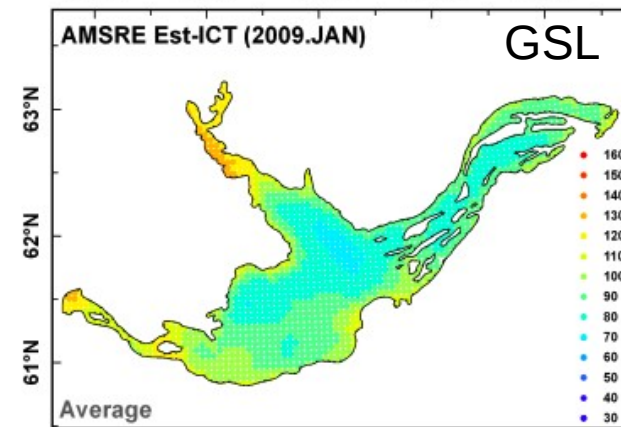**North Slope of Alaska**

Other products generated by UW

Pan-Arctic
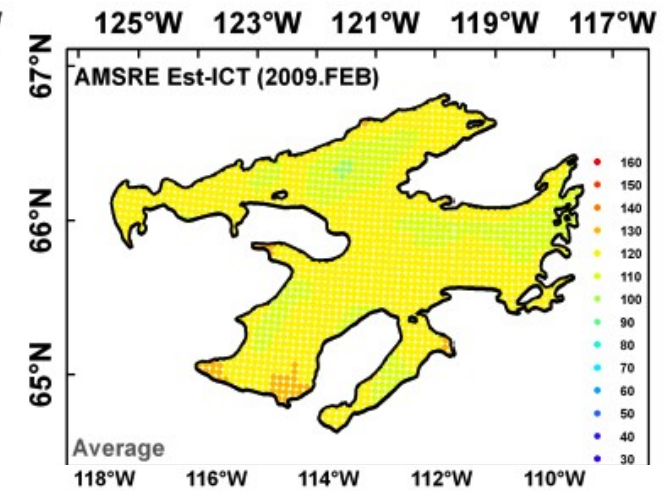
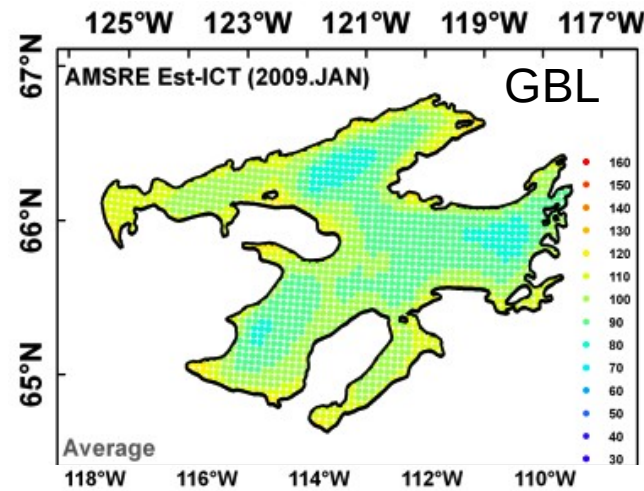LST MONTHLY
MEAN – AATSR
(JULY 2008) –
25 km resolution

Other products generated by UW

ICE THICKNESS
MONTHLY
MEAN – AMSR-E
10 km resolution

Kang et al., in prep.

North Hydrology – More Information

- See me this week or send me an e-mail at crduguay@uwaterloo.ca

- A temporary website with some project information has been set-up but will move to a new address in 1-2 months: http://snowcore.uwaterloo.ca:8080/

Thank you!